2000 CALFED Science Conference
Session Notes

Effects of Contaminants and Other Stressors

Session Chairs: Valerie Connor and Victor DeVlaming
Session Notetakers: Kelly Briggs, Robert Holmes, and Karen Larsen

Methyl mercury bioaccumulation in re-flooded wetlands in the San Francisco Bay-Delta ecosystem - Thomas Suchanek, UC Davis

Issue/problem: This study evaluates the potential for methyl mercury production in recently flooded areas of the San Francisco Bay Delta. This was a two-part presentation. Dr. Suchanek discussed the regional perspective of watershed sources of mercury (Hg) and Dr. Slotton presented results from studies of recently flooded wetlands.

Approach: Historic mercury mines in the Coast Ranges and gold mining activities in the Sierras are continuing sources of Hg to the Delta. Elevated levels of Hg have been found in fish tissue and fish consumption advisories have been posted in lakes and reservoirs throughout California. Conditions found in wetland environments facilitate the production of methyl mercury, a toxic form of the metal that is easily bioaccumulated. Recently flooded agricultural tracts in the Bay-Delta may be sources of methyl mercury to the system. This study looked at a series of islands and agricultural tracts that have been flooded by levee breaches between 3 and 67 years ago. There were 60 sites located in a variety of environments, from low flow, stagnant conditions to rapidly flowing channels. Mercury concentrations in biota were measured to assess methyl mercury productions at the different sites.

Relevance to CALFED: Before wetlands restoration activities in the Bay-Delta are initiated, the potential for methyl mercury production in recently flooded wetlands and subsequent bioaccumulation should be understood.

CALFED UC Davis Delta mercury study: year 2 findings - Darrel Slotton, UC Davis.

Issue/problem: This study evaluates the potential for methyl mercury production in recently flooded areas of the San Francisco Bay Delta. This was a two-part presentation. Dr. Suchanek discussed the regional perspective of watershed sources of mercury (Hg) and Dr. Slotton presented results from studies of recently flooded wetlands.

Approach: The study looked at differences in mercury exposure in different microhabitats throughout the Bay-Delta ecosystem. Mercury concentrations were measured in surface sediments and biota (Corbicula and inland silversides). Microcosm experiments measured the potential for methyl mercury production in Delta sediments. This presentation focused on results from the second year of the study.

Key findings: Sediment concentrations ranged from 0.01 to 0.3 ppm total mercury. Elevated concentrations were found in fine-grained, depositional areas. Microcosm experiments confirmed that the organic, rich sediments (such as wetland sediments) had greater potential for methyl mercury production. For example, the North Delta sediments showed lower potentials than the Central Delta sediments that are richer in organic matter. Corbicula mercury concentrations were elevated in the West Delta. However, it was discovered that bivalves contain a lot of inorganic Hg and therefore these measurements may not be representative of methyl mercury concentrations.

Inland silversides provided the best data available for methyl mercury bioaccumulation in the Bay-Delta. High Hg concentrations were found in the North Delta inflow and the Cosumnes River, also in Mud Slough and a hot spot in the West Delta. Hg concentrations in the South Delta were low. Surprisingly Hg concentrations in the Central Delta were the lowest. Central Delta sediments tend to have elevated Hg concentrations and high methyl mercury potentials.

Relevance to CALFED: Before wetlands restoration activities in the Bay-Delta are initiated, the potential for methyl mercury production in recently flooded wetlands and subsequent bioaccumulation should be understood.

Discussion key points: During the question and answer section, the discussion included how tidal flows may be affecting bioaccumulation in the Central Delta.

Persistent contaminants of human health concern in sportfish from the Delta and Sacramento River - Jay Davis, SFEI.

Issue/problem: Results from the following three monitoring programs were presented; the San Francisco Estuary Institute's Delta Fish Study, the CALFED Mercury Project, and the Sacramento River Watershed Program. The objectives of these programs were to determine if contaminants occur at levels of concern to human health, track trends and evaluate management measures, and to identify methods and species to make the data comparable. A consumption advisory is in effect for the Bay and Delta, and may be expanded into other portions of the Central Valley once a robust dataset is developed.

Approach: This study assessed levels of chemical contamination (mercury, PCBs, and organochlorine pesticides) in largemouth bass and white catfish in the

Delta, the Sacramento River and the San Joaquin River. USEPA guidance was used to calculate screening values for each contaminant for use in evaluating the results.

Key findings: Overall the study found contaminant concentrations above screening values at the majority of sample sites. Elevated concentrations of mercury in fish were found in the Feather River, the North Delta and the South Delta. Mercury concentration in fish tissue generally increased with the length of the fish, but there were a lot of scatter in the data. Mercury concentrations were comparable to those that led to the consumption advisory for the Bay. Localized areas of elevated PCB concentrations were found in fish from the North and South Delta. Nine of 49 fish tissue samples had elevated DDT concentrations. The highest concentrations of DDT were found in fish from the South Delta.

Relevance to CALFED: Future CALFED restoration projects and management measures should take localized areas of elevated contaminant concentrations into consideration. Further data on where people fish and which species they catch is necessary. A long-term systematic monitoring program is recommended to track trends in contaminants of concern relative to regulatory targets. This monitoring should include the San Joaquin River watershed, which has been largely neglected to date.

Discussion key points: Discussions after the presentation concerned the lower mercury concentrations found in fish of the Central Delta.

Regulatory aspects of mercury in California waterways - Janis Cooke, Central Valley Regional Water Quality Control Board

Issue/problem: The Central Valley Regional Water Quality Control Board (RB) is responsible for developing Total Maximum Daily Loads (TMDLs) for water bodies impaired by mercury contamination. The main source of intake, excepting occupational exposure, is through consumption of fish containing mercury. The fetus is the most sensitive life stage to toxic effects of mercury.

Approach: Numeric targets are required for TMDLs to determine if loads are effectively being reduced. The RB has made the most progress on the TMDL for Clear Lake. Mercury levels in fish tissue will be used as the primary parameter for monitoring because of its relationship to human and wildlife health risks. Acceptable fish tissue concentrations of mercury can be derived using the following simple equation:

$$\frac{\text{Reference dose} * \text{consumer body weight}}{\text{Consumption rate}} = \text{acceptable level of Hg in fish tissue}$$

The RB examined various options for the variables in this equation. For

purposes of the draft numeric target for the Clear Lake TMDL, the following assumptions for humans were made:

- Reference dose. US EPA's value of 0.1 microgram mercury per kilogram of bodyweight per day as the maximum safe intake of mercury, based on recent validation of this value by National Academy of Sciences.
- Body weight = 65 kg. USEPA's standard bodyweight for an average pregnant woman.

Consumption Rate = 60 g/day. Rates of consumption of sportfish vary widely. A subpopulation at Clear Lake has reported consumption of an average of 60 g/day of fish from Clear Lake.

Key findings: Using these assumptions, a safe mercury level for human consumption was derived to be 0.1 micrograms of mercury per gram of fish, wet weight (ppm). Similar calculations done for fish-eating wildlife are in the same range (e.g., 0.09 ppm for protection of western grebe; 0.21 ppm for bald eagles). Wildlife tend to eat smaller fish that have less mercury than fish eaten by humans. Lacking data on existing impacts of mercury on wildlife, RB concluded that lowering levels of mercury in fish sufficiently to protect humans would protect wildlife as well.

Relevance to CALFED: Mercury levels in fish from the central Delta, although lower than same-size fish from lower Sacramento, Feather or San Joaquin Rivers, may pose risks to wildlife and frequent human consumers of fish. Effects of wetlands restoration and Delta water flow changes on net mercury methylation in the Delta need to be anticipated and evaluated.

Discussion key points: Existing data gaps include: factors controlling the methylation of inorganic mercury, mercury levels in a wide variety of fish species, the impacts of mercury on local wildlife, and fish consumption patterns in the Delta and Central Valley. CALFED projects are addressing some, but not all of these data gaps. The process used for the Clear Lake TMDL is expected to be used in development of other mercury TMDLs. However, the calculation of mercury targets for future TMDLs will be site-specific and will vary for each impaired waterbody.

The contribution of algal biomass to oxygen depletion in the lower San Joaquin River - Peggy Lehman, DWR.

Issue/problem: For thirty years dissolved oxygen concentrations below 5 mg/L have been measured in the deep-water ship channel in the lower San Joaquin River during the fall. The dissolved oxygen frequently falls below the EPA standard of 5 mg/L for aquatic health and the Regional Water Quality Control Board standard of 6 mg/L for upstream migration of fall-run Chinook salmon.

Approach: The authors measured water quality variables and chlorophyll a concentration, an estimate of algal biomass, at sites along the deep-water ship channel. They also measured the net tidal exchange of chlorophyll a, total organic carbon and dissolved oxygen concentration at the San Joaquin River at Vernalis, Mossdale and Channel Point in order to determine load from upstream. Using modeling, they compared the algal load from the deep-water channel with upstream and calculated the oxygen demand from algal biomass in the channel.

Key findings: Chlorophyll a concentration decreased by a factor of 4 since the 1970's and suggested algal biomass may not be as important to oxygen demand in the channel as it was previously. A factor of two decrease in chlorophyll a concentration between Vernalis and Channel Point, the entrance to the deepwater channel, suggests previous estimates of algal biomass load to the deep-water channel may be high. Algal load from *in situ* algal growth can exceed that from upstream, especially late in the season. Water quality profiling indicated an absence of water temperature or salinity gradients as causal factors for the increased oxygen demand near the bottom. In addition, high ammonia concentration suggested nitrification was a strong draw on dissolved oxygen concentration. The authors suggest solutions to the dissolved oxygen problem must address algal load in addition to a suite of physical variables including residence time, channel configuration and water temperature.

Dissolved oxygen and temperature modeling of the Delta - Hari Rajbhandari.

Issue/Problem: During the summer and fall, dissolved oxygen (DO) tends to fall below the saturation point in the San Joaquin River near Stockton. CALFED is working on this issue, and the Central Valley Regional Water Quality Control Board is developing a Total Maximum Daily Load (TMDL) through a stakeholder process to address this condition. A DO model (DSM2) is being developed as a tool to assist in this process. Processes affecting DO levels include advection, dispersion, mixing, and kinetic interactions (the focus of this talk). Mass transfer rates for sources and sinks of constituents affecting DO are temperature dependent. A goal of this model is to characterize DO mass balance.

Approach: There are two main steps for developing the model simulation: (1) hydrodynamics, and (2) water quality. Hydrodynamic model inputs include the flow at Vernalis (4,700 to 7,000 cfs); combined exports (4,000 to 13,000 cfs); no closure at the head of Old River; effluent load (30 to 60 cfs); and agricultural drain diversions. Water quality model inputs include DO; temperature; biological oxygen demand (BOD); nutrients and chlorophyll at the river and seaward boundaries; effluent loads (BOD, ammonia, etc.); meteorology (air and wet bulb temperature, wind speed, cloud cover, and atmospheric pressure); rate coefficients; and agricultural drain effluents. In developing the simulation, hourly variations of temperature and DO at Mossdale were used as an approximation for the field data at Vernalis.

Key Findings: Work has been done to validate the model. In the San Joaquin River at Stockton, modeled (predicted) conditions matched very well with observed conditions. Rate adjustments were needed for algal growth, respiration and settling; ammonia decay; organic nitrogen decay; BOD decay; NH3 to NO2 oxidation; NO2 to NO3 oxidation; re-aeration; and sediment oxygen demand. When flows are dominant, transport is governed mostly by flow. It appears that the model performs best when flows are dominant (high). At low flow conditions, other factors come into play (e.g., algal dynamics).

Relevance to CALFED: Maintaining proper DO levels are critical to fish survival in the bay-delta watershed system. Development of this model will provide a needed tool for CALFED, and those working on the TMDL for the San Joaquin River near Stockton, to address the low DO conditions observed during the summer and fall.

Key Points: Preliminary work to validate the model has been encouraging, but calibration is ongoing. The process is very data intensive, and narrowing the data gaps will help. There are plans in the near future to expand the model to upstream of Vernalis, which will greatly further development of the model. This is due to the fact that there is additional information on water quality further upstream of Vernalis, thus extending simulations to further upstream of Vernalis will help with the validation of the model. As DSM2 is further refined, it is expected this model will be a useful tool for CALFED and the TMDL process.

TMDL development to control DO depletion in the San Joaquin River deep-water channel - G. Fred Lee, Lee & Associates.

Issue/problem: A Total Maximum Daily Load (TMDL) must be developed because dissolved oxygen (DO) concentrations in the Deep Water Ship Channel (DWSC) near the Port of Stockton fall below the Regional Water Quality Control Board's water quality objective for protection of aquatic life during summer and fall. The low DO during this time period could prevent chinook salmon from returning to the San Joaquin River (SJR) Watershed. The TMDL program must be in place by 2002 to solve this problem.

Approach: The sources of the oxygen-demanding constituents were discussed as well as factors that influence DO depletion and issues associated with TMDL development.

Key findings: The transition from the riverine environment of the San Joaquin River to the deep-water channel leads to the low DO problem. Algae are not present in the photic zone of the DWSC and respiration is extremely high. Upstream control of carbonaceous BOD, nutrients (N and P), and nitrogenous oxygen demanding constituents must be considered. Upstream SJR sources of

the oxygen-demanding load need to be reduced by 50,000 – 80,000 pounds a day during summer and fall. Sources of the oxygen-demanding load in the San Joaquin River include runoff from cities, agriculture, groundwater recharge and discharge, dairies, riparian lands and wastewater treatment plants. An upstream water diversion from the San Joaquin River into the Old River decreases the flow and adds to the decreased DO problem in the DWSC by limiting the flow necessary to flush the high BOD through the DWSC into the Sacramento-San Joaquin River Delta. Aeration has been suggested as one way to control algal growth and die off in the DWSC. Controlling the DO problem in the DWSC will be expensive. It is not clear who will pay to fix the DO problem (dischargers of oxygen demanding constituents, Port of Stockton beneficiaries, flow diverters or manipulators, or others). All of the issues mentioned above are pertinent in the development of the TMDL to control DO depletion in the DWSC.

Selenium in the San Francisco Bay and Delta: historical trends and present status -
Gregory Cutter, Old Dominion University

Issue/problem: Elevated dissolved selenium concentrations have been measured in the San Francisco Bay and in the tissue of key species. Primary producers take up dissolved selenium which bioaccumulates and then moves through the food chain causing toxicity to fish and birds.

Approach: The authors examined the biogeochemical processes affecting the transport of selenium to the Bay by measuring selenium concentrations along transects within the Bay.

Key findings: Selenium concentrations in the Bay have decreased since the 1980's. In the 1980's, unusually high concentrations of selenite were measured. The source was traced back to oil refineries discharging to the Bay and its tributaries. Since then, the refineries have decreased the amount of selenite discharged to the Bay. This has caused a decrease in selenite concentrations to one third of what was measured in the 1980's. However, suspended particulate selenium concentrations are still high. Some selenium is transported in from the Sacramento River and future changes in water management will allow higher selenium in the San Joaquin River to enter the estuary.

Relevance to CALFED: Selenium is essential, however, in certain chemical forms and concentrations it is toxic to fish and birds.

Bioaccumulation of selenium by phytoplankton - Stephen Baines, SUNY Stony Brook.

Issue/problem: Dissolved selenium primarily enters the food chain in the San Francisco Estuary from assimilation by phytoplankton. Although Se is an essential element, bioaccumulated levels in the food chain could cause toxicity to higher trophic levels of wildlife.

Approach: Radio labeled isotope Se-75 was used to assess relative availability of selenite (Se(IV)), selenate (Se(VI)), and organic selenides (Se(-II) to phytoplankton. Variability in Se bioaccumulation among algal species was then evaluated. In addition, cellular Se contents and dependence upon ambient Se concentrations was measured.

Key findings: A quick summary of a number of experiments was presented. Se(IV) and Se(-II) are taken up by algal cells and in higher amounts than Se(VI). Addition of Se(IV) reduced algal uptake of Se(-II), suggesting internal control pools by the algae. Cellular Se content of five different algal species varied by almost four orders of magnitude when exposed to 4.5 nM Se(IV) or Se(-II), and five orders of magnitude when exposed to 0.15 nM Se(IV). Therefore, species composition of phytoplankton communities in could have large influence of Se accumulation and trophic transfer in food webs. In another experiment, the Se content of the diatom, *Thalassiosira pseudonana*, varied asymptotically with Se(IV) concentration. It was concluded that organic selenides are a significant source of Se to the food web; and, given various assumptions including feeding rates, that phytoplankton species composition and selenite/selenide concentrations can determine and predict the Se tissue contents of resident herbivores, such as bivalves, in the San Francisco Bay.

Relevance to CALFED: Se can be a toxin. Bioaccumulation of Se is complicated and must be understood in the San Francisco Estuary for correct management.

Bioaccumulation of selenium in the food web of San Francisco Bay: importance of feeding relationships - Robin Stewart, USGS.

Issue/problem: The mechanism for selenium bioaccumulation in a food web is complicated and results in wide variability in selenium concentrations between species in San Francisco Bay. Because of this variability it was necessary to identify species at risk and the species that are the best indicators of bioavailable selenium in the Bay. A large component of identifying these species was mapping out feeding relationships of San Francisco Bay organisms.

Approach: Stable isotopes were used to establish the feeding relationships within the San Francisco Bay food web. The advantage of using isotopes is that

relationships can be established qualitatively and quantitatively. The information collected from these studies can then be used in biokinetic models.

Key findings: Extensive analysis of selenium in organisms from Grizzly Bay was conducted in fall, 1999. Within the invertebrate food chain, *Potamocorbula amurensis,* a bivalve, had the highest assimilation of selenium. Lower concentrations of selenium were found in crustaceans. Fish species had widely varying selenium concentrations. Sturgeon had bioaccumulated the greatest relative selenium concentrations with values above the threshold for reproductive toxicity. Splittail were at the lower end of the window defining the threshold of toxicity. Striped bass had relatively lower selenium concentrations. Bird species were analyzed for selenium, but were found to have levels much lower than toxic thresholds. The data suggests food webs relying heavily on clam consumption had the highest selenium concentrations (sturgeon), while those based on crustacean consumption had lower selenium concentrations (striped bass).

Relevance to CALFED: Using isotopes to trace food web relationships and areas of highest occurring selenium can help the CALFED program to manage for the species at highest risk and the areas of highest selenium concentrations.

Discussion key points: Using the stable isotopes showed that it was not necessarily top predators of the food web that had the highest selenium concentrations, but those that fed on lower trophic organisms high in selenium. Understanding mechanisms that control selenium bioaccumulation by different invertebrates is thus important to predicting which predators might be most at risk.

Assimilation of selenium from food by striped bass larvae - Nicholas Fisher, SUNY Stony Brook.

Issue/problem: Many fish get selenium from their food and small changes in their tissues could cause toxicity in the fish. Subsequently, little is known of the assimilation and excretion of Se from food by fish.

Approach: This study used radio labeled Se to estimate Se assimilation efficiency (in) and e flux (out) rate of two sizes of juvenile striped bass, identified Se in different parts of the body of the two sizes of fish, and used modeling to predict Se concentrations in San Francisco Bay.

Key findings: Digestion is simple and fast. Assimilation of Se from food was greater than observed for Cd, Zn, Ag, and Cu. The e flux rates were also high. E flux rates averaged 9 – 10% a day. Little difference was found between larger fish and smaller fish for Se assimilation efficiency and e flux rates. Most of the Se in a small fish was found in the head. However, the fish liver had the highest Se concentrations because it does not weigh as much as muscle or the head. A model used to predict Se concentrations in San Francisco Bay was discussed.

Comparisons of predictions with field data indicated highly comparable results for Se in muscle and liver tissues.

Relevance to CALFED: San Francisco Bay fish feed on food enriched with Se.

Multi-level study of environmental endocrine disruptor effects in an estuarine crustacean – Mark Snyder, Bodega Marine Laboratory.

Issue/problem: Many types of endocrine disruptors (EDCs) are being transported to surface waters of California causing developmental effects in aquatic organisms.

Approach: The authors first will identify sentinel species then develop a set of response variables. The study will be an integration of population level effects and individual developmental effects looking at the estuarine shrimp, *Palaemon macrodactylus*. The authors will video behavior as well as monitor ovarian development to hatching. Also, biomarkers such as cytochrome P450 enzymes and stress proteins will be monitored to determine biochemical effects at the subcellular level in embryos, larvae, and adults.

Key findings: This study was presented as a proposal of future work. Initial results prove that shrimp embryos develop normally between 5-30% salinity regardless of adult female environmental history. Tributyltin (TBT), a known EDC and continuing problem in worldwide estuary and near shore environments, appears to be toxic to *P. macrodactylus* embryos at concentrations ≤ 10 parts per trillion (average estuarine levels).

Relevance: The proposed project will develop a useful field tool to identify sublethal effects of EDCs measured in surface waters both at the individual and population level.

Episodic toxicity in the San Francisco estuary - R. Scott Ogle, Pacific EcoRisk.

Issue/problem: The Regional Monitoring Program (RMP) was sampling the San Francisco Estuary to characterize the sources, fate and distribution of contaminants. There did not appear to be any toxicity until sample collection coincided with a storm event in 1996. Pesticides moving off site and into surface water were suspected to be the source of toxicity.

Approach: The Regional Monitoring Program began to monitor episodically at urban creeks and Mallard Island using *Mysidopsis bahia* and *Menidia beryllina* as test organisms to study the effects of stormwater runoff.

Key findings: Over the last three years, the Regional Monitoring Program has seen a decrease in the frequency and magnitude of toxicity to mysids during these storm events. The same samples tested with *Menidia beryllina*, the inland silverside, showed a trend of increasing toxicity to the *Menidia* over time. Complete toxicity to *Menidia* was seen in 24hours in samples that were not toxic to *Mysidopsis*. This change in species toxicity has been attributed to the change in pesticide use. The use of organophosphate pesticides, which mysids are sensitive to, has decreased while the use of pyrethroids, which fish are sensitive to, has increased.

Relevance to CALFED: Monitoring tools must be adapted as contaminants change in magnitude, frequency and location. The program must be instep with current land and toxicant use practices to successfully monitor the health of the ecosystem. Pyrethroids adsorb to sediments and currently there is no monitoring of sediments in San Francisco Estuary. With the increase in valley wide usage, CALFED should consider implementing sediment monitoring to more completely understand the effects of pyrethroids.

Discussion key points: Frequent monitoring of water quality increases the likelihood of observing toxic pulses that can easily be missed in monthly monitoring. There appears to be a strong transition in pesticide usage from organophosphate pesticides to pyrethroids. Standard or current monitoring protocols may not be suitable to accurately characterize the impacts of pyrethroids. Other contaminants besides pesticides may also be a source of toxicity in the San Francisco Estuary.

Pesticides in the Sacramento- San Joaquin Delta: state of our knowledge - Kathryn Kuivila, USGS

Issue/Problem: There are four major distribution patterns of pesticides in surface waters that correspond with winter storm runoff of dormant orchard sprays; spring late rains runoff of alfalfa pesticides, late spring/ early summer rice drainage, and summer irrigation drainage of truck crops. But pesticide use is constantly changing, and many pesticides are not being monitored. There are a lot of data gaps on pesticides and their effects on the biota in the Delta.

Approach: Adaptive analysis is needed to be able to continually evaluate the effects that pesticides are having in the Delta. One method of determining the effects of pesticides is to study specific species at their critical life stages (larval and juvenile to narrow down the locations and timing of sampling.

Key findings: Pesticides vary widely spatially and temporally in the Delta. There is very little data on pesticides in the back sloughs of the Delta. Because these sloughs are used as nurseries for many fish species, more resources should be dedicated to filling these data gaps. A study looking at the potential effects of

pesticides on the Delta smelt showed that peak concentrations of pesticides coincided with high densities of smelt at the confluence of the Sacramento and San Joaquin Rivers.

Relevance to CALFED: Dissolved pesticide levels can be monitored and analyzed for species exposed to the pesticides. However, very little is known pesticides associated with sediments, their bioavailability, and the effects on benthic and other communities in the Delta.

Discussion key points: Currently there are distinct seasonal patterns to pesticide concentrations in the Delta, however the majority of pesticides are not being monitored and those that are being monitored are changing in use. Very little information is known about the effects of pesticides in the ecologically important back sloughs of the Delta or the effects of sediment related pesticides. Pesticides have long residence times in the Delta and have complicated interactions with biota that are not yet completely understood.

Occurrence and potential impacts of op pesticides in Central Valley urban creeks - Kathleen Russick, Russick Environmental Consulting.

Issue/Problem: The Sacramento Stormwater Management Program has identified Organophosphate (OP) pesticides as the highest priority pollutants in Sacramento area urban creeks. The Sacramento Stormwater Program received CALFED funding to study the occurrence and impacts of OP pesticides in urban creeks. The focus of this study has been on Arcade Creek, which is representative of many other central valley urban creeks impacted by OP pesticides such as diazinon and chlorpyrifos. This talk was a summary of the work conducted for this study to date. Key issues the study seeks to address are:

- What are diazinon and chlorpyrifos concentrations through the year in Arcade Creek?
- How long do the toxic pulses of these pesticides persist?
- How do diazinon and chlorpyrifos concentrations vary along the length of the creek?
- What are the amounts of diazinon and chlorpyrifos contributed from rainfall?

Approach: There are two primary goals of the CALFED project: 1) to study the impacts of OP pesticides in Sacramento area waterways through chemical monitoring for diazinon and chlorpyrifos and toxicity testing (this includes analyses of samples from creeks, rivers and stormwater), and 2) public outreach and education through the Master Gardner Program. Today's presentation will be on the chemical monitoring portion of the study. To date, there have been 12 months of intensive OP pesticide monitoring (from April 99 to April 2000) at five

sites along an 11-mile stretch of Arcade Creek. The land use along this stretch is mixed residential and commercial. Additionally, five storm events were monitored last season, and analyses conducted of samples from the Sacramento and American Rivers, stormwater and rain. ELISA was used to analyze diazinon and chlorpyrifos concentrations, with a GC confirmation of ELISA results for 10% of the samples.

Key Findings: During late spring to early summer, elevated concentrations of diazinon and chlorpyrifos were measured in the creek. Concentrations drop off in later summer, only to rise again after the rains begin. For diazinon, the No Observed Effect Concentration (NOEC) for C*eriodaphnia dubia* was exceeded in 11 of the 15 monitoring events. For chlorpyrifos, the NOEC for C*eriodaphnia dubia* was exceeded in 14 of the 15 events. It is important to note that for these two pesticides, the toxic effects to C*eriodaphnia dubia* are additive. Diazinon concentrations were observed to decrease from upstream to downstream sampling locations. A hypothesis for this observation is that exfiltration of groundwater is occurring in the creek (i.e., groundwater is seeping into the creek which dilutes diazinon concentrations). Similar observations were made with chlorpyrifos.

It is believed that rainfall contributes to the diazinon and chlorpyrifos concentrations in the creek, but it is not clear if the source of these pesticides in rain is local or from agricultural sources in the Sacramento Valley. Toxicity testing using C*eriodaphnia dubia* was performed for three storm events. Mortality was 100% within 24 hours for the November sampling event. For the February event, mortality was 35 to 100%, and mortality was 100% within 24-48 hours for the April event. Ninety percent of the toxicity was associated to OP pesticides.

Relevance to CALFED: Water quality is a key component in the health of the bay-delta watershed system and an area of focus for CALFED. Urban areas contribute to contaminant loadings to the bay-delta system. Developing information on concentrations of contaminants that are detrimental to aquatic organisms, the duration and frequency of toxic pulses, as well as the spatial aspects of these pulses, will help with the identification of the sources of these contaminants, and hopefully provide insights to appropriate Approaches to reduce loadings from urban sources.

Key Points: Diazinon and chlorpyrifos concentrations persist at levels toxic to C*eriodaphnia dubia* and other sensitive arthropods through most of the year. Arcade Creek frequently exceeds the California Department of Fish and Game Hazard Assessment levels for diazinon. To provide a develop a more complete profile of Arcade Creek, the Sacramento Stormwater Program plans to expand the breadth of its creek monitoring. This expansion will include physical habitat assessments and bioassessments, an evaluation of physical stressors, and sediment toxicity testing.

Question:

Q: Have pyrethroids been evaluated in this study, or will they?
A: DPR Pesticide Use Reports will be evaluated. Local PCA's have reported that use of pyrethroids has increased.

Evaluation of methods to reduce off-site movement of dormant spray pesticides from orchards - Frank Zalom, US Davis.

Issue/Problem: Organophosphate (OP) pesticides, particularly diazinon and chlorpyrifos, have been routinely detected in waterways at concentrations exceeding EPA standards. Some of these pulses coincide with winter storm events following applications of these pesticides to dormant orchards in the Sacramento and San Joaquin watersheds. Potential sources of OP pesticides in the watersheds include winter agricultural activities, urban sources and tailwater from irrigation. CALFED has funded a team of researchers from UC Davis to investigate this issue. This talk was a summary of the work conducted to date.

Approach: The three keys areas of this project include: 1) the development of information matrices on alternative practices for in-season agricultural uses and urban uses (a matrix for dormant spray alternatives has already been developed by the team in a previous project); 2) education and outreach (urban fact sheets; dormant spray alternatives information sharing through the Sacramento River Watershed Program, newsletters and trade journals; and development of a toxicology primer for urban and agricultural audiences); and 3) field studies on best management practices (BMPs) and hydrology, transport mechanisms, alternative practices, alternate bioassay species, and urban contributions of OP pesticide loading to the watersheds. The urban information matrix involves uses of OP pesticides on ants, fleas, spiders, lawn insects and aphids. The in-season agricultural matrix focuses upon OP pesticide uses in almonds, apricots, peaches, plums, and prunes. An orchard in Artois is being used to evaluate BMPs and hydrology. Replicate orchard blocks have been established with sod, resident vegetation, clover and bare ground. Half of the blocks are being treated with diazinon and half with esfenvalerate, and concentrations of these pesticides in the runoff are being measured to evaluate the effectiveness of different types of cover in reducing pesticide runoff. Toxicity testing with the field runoff is also being conducted (the Lowest Observed Effect Concentration (LOEC) for *Ceriodaphnia dubia,* and mortality for fathead minnows). Members of the research team have developed and are refining an autosampler for orchard runoff. Hydrology at the Artois orchard is also being assessed. The team is developing appropriate methodologies to determine how much water is moving across orchards and the effects different soil types have on runoff. The team is using simulated runoff events with sprinklers and developing hydrographs to compare with observed runoff. Two sites in Modesto are being used to evaluate

agricultural and urban contributions of OP pesticides. One site has primarily urban runoff and one has primarily agricultural runoff. The target pests of dormant organophosphate sprays in orchards are Peach Twig Borer and San Jose Scale. Mealy Plum Aphids and Leaf Curl Aphids are key pests in prunes and plums that are also targets for the dormant sprays. For alternative practices, reduced risk pesticides, alternative application timing and alternative volumes are being evaluated. The team is also initiating a study of sprayers that could help to mitigate the problem.

Key Findings: For the evaluation of urban and agricultural contributions of OP pesticides, sampling for the first storm of 1998 resulted in samples that produced 100% mortality in *Ceriodaphnia dubia* from the urban runoff site. The second storm resulted in samples that produced 100% mortality in *Ceriodaphnia dubia* from both the urban and agricultural runoff sites.

Relevance to CALFED: Water quality is a key component in the health of the bay-delta watershed system and an area of focus for CALFED. Developing information on the effectiveness of BMPs and alternative practices for urban and agricultural uses of OP pesticides is a key step in reducing OP pesticide loadings to the bay-delta watershed system. The identification of effective alternative products and practices will facilitate reduced use of OP pesticides, and BMPs are needed that will reduce off-site movement in cases where OP pesticides are used.

Key Points: Both urban and agricultural sources are contributing to OP pesticide loadings to the watershed in the Modesto area, but this is probably true of other urban and agricultural settings in the Central Valley as well. With regard to agricultural uses, many orchards can do without dormant sprays. With good pest monitoring, amounts of OP pesticides applied can probably be reduced by 50%. However, pest monitoring is labor intensive. Bt sprays only address Peach Twig Borer, but are an effective alternative if this is the key pest problem in a particular orchard. High rates and volumes of dormant spray oil are probably satisfactory for low to moderate infestations of scales. New products or Approaches need to be developed for aphid control. Some possible products are imidachloprid, thiamethoxam and pirimicarb.

Questions:

Q: With regard to the different types of sprayers, is the group looking at the Smart Sprayer?
A: Yes. They worked with the engineer of that sprayer about ten years ago, and are bringing him back on board with this work. Their deposition study using different spray volumes was conducted with a Smart Sprayer.
Q: For the orchard runoff work, are you going to do a mass balance analysis?

A: We have not done a mass balance analysis, but this should be done. We simply don't have the funding in our present contract to look at the fate of all the material emitted from the sprayer.

Cumulative ecological risk assessment – a framework for developing explicit conceptual models in CMARP program design – Nicholas Poletika, Dow Agrosciences LLC.

Issue/problem: A framework of explicit conceptual models is necessary to account for multiple stressors so that important interactions can be considered, monitoring and research areas can be prioritized, and an adaptive management Approach can be implemented.

Approach: The author uses a cumulative ecological risk assessment to look at multiple stressors in a watershed (Orrestimba Creek). The conceptual model includes comparing distributions of daily concentrations of chemicals in the water, characterization of temporal patterns, determination of taxa at risk, and interpretation of the ecological relevance.

Key findings: The author found that the major stressor to native taxa in Orrestimba Creek is invasive species. Organophosphorous (OP) pesticides were found unlikely to be impacting fish populations or invertebrate production.

Discussion: Discussion focused on whether OP pesticides can be discounted as a major stressor in the system.

Sediment quality assessments in San Pablo and Suisun Bays - Bruce Thompson, SFEI.

Issue/problem: This study compared three methods of assessing sediment quality: sediment contamination, sediment toxicity, and benthic organisms.

Approach: Sediment contamination was assessed using the ERM (Effects-Range Median) method. Sediment toxicity tests were conducted using bivalve embryos and the amphipod Eohaustorius esturius. Benthic organism bioassessments were conducted by comparing species abundance and diversity between test sites and reference sites.

Key findings: Sediment contamination tests and sediment toxicity tests showed similar “hot spots” of contamination in the test area. Toxicity tests measured toxicity during wet periods and no toxicity during dry periods. Results from the three indicator tests are not always correlated. There is a need to reconcile and understand the relationships between the different tests. Other causes of toxicity, in addition to metals, should be evaluated.

Relevance to CALFED: Reliable indicators of sediment toxicity are important CALFED management strategies such as; evaluating effectiveness of management decisions, identifying hot spots of contamination and the impacts of stressors.

A new approach to predicting the risks posed by contaminated sediments - Donald Weston UC Berkeley.

Issue/problem: The determination of the bioavailable fraction of sediment associated contaminants.

Approach: A polychaete digestive fluid assay was compared to bioaccumulation, a traditional means of assessing bioavailability, by a clam held in sediments contaminated by trace metal, PAH's, and PCB's from a naval harbor in San Francisco Bay.

Key findings: Digestive fluid extraction results were an excellent predictor of clam bioaccumulation for both metals and the organics. Also, digestive fluid assay indicated that only about 1 % of the sediment bound metal was extractable. Other data sets were presented that also demonstrated the usefulness in predicting bioaccumulation of other contaminants by digestive fluid assays. In addition, the polychaete digestive fluid was found to be representative of other taxa when compared to digestive fluid assays using other invertebrates and seawater.

Relevance to CALFED: This technique will allow the tracking of bioavailability differences across habitats, which could have a large effect on restoration activities in the San Francisco Estuary.